PLUTON TURN ON THE FUTURE

SQTA®

MONITORING AND PROTECTION SYSTEM

CITY ELECTRIC TRANSPORT ■
RAILWAYS ■ METRO

UNIVERSAL SOLUTION FOR TRACTION NETWORK CONTROL, MONITORING AND PROTECTION

Requirements for traction power supply quality and reliability are growing together with the development of high-speed passenger transportation, increase of traffic flows, power and speed of motion in the world. Thus, there arises a need for more efficient traction network control and protection systems.

Modern traction power supply systems require application of reliable intelligent microprocessor relay protection devices that provide guaranteed uninterrupted power supply, allow saving of contact network infrastructure in case of emergencies, and facilitate restoration of power system and rolling stock power supply without failures in traffic schedule, minimizing probability of unscheduled electricity consumers outages, damage to expensive equipment and other emergency recovery costs.

Based on international practices, our in-house developments and implementation of RPA and PLC systems, we have created a solution that combines such products into a unified modular multicapable system. Pluton specialists have developed an innovative SOTA® system — a combined microprocessor-based relay protection device.

SOTA® system is designed to combine the functions of PLC and protection system. Application of modular architecture systems in the devices along with modern surface-mount technologies provides high reliability, high processing power and speed, as well as high precision in electrical and time intervals measurements. All this makes it possible to increase performance of computing processes and the sensitivity of protective functions.

SOTA® BENEFITS

- / modern innovative system;
- / compliance with the main **IEC 61131** series international standards;
- / native software debugging environment;
- / support of multiple protocols, including **IEC 61850**;
- / software for IEC 61850 protocol (CID, ICD) configuration files setting — both by the developer and the substation configurator.

SOTA® SYSTEM FUNCTIONS

- Traction network parameters **monitoring**
- **Protection** of traction network against short circuit currents and harmful overloads
- Cubicle operation **control** (PLC)
- Waveforms recording in case of emergency processes
- Events logging
- Storage of daily trends
- Data storage for further analysis
- System remote control
- Support of multiple communication protocols

SOTA® SYSTEM FUNCTIONS

Control

/ cubicle or other automated system operation control;

/ due to application of visualization panel with liquid crystal graphic display, the required information is displayed and switching units control is performed in convenient intuitive form;

/ PLC operation algorithms programming using IEC 61131–3 standard languages (ST, IL, LD, FBD, SFC).

Protections

/ protection of traction network against short circuit currents and harmful overloads.

Monitoring

/ traction network actual electrical parameters measurement and displaying;

/ daily trend maintenance for the line load analyzing.

Communication with the upper control level

/ system remote control (telecontrol system commands receiving);

/ reading of traction network actual electrical parameters by the upper level system from SOTA® system (or their independent transmission when using IEC 61850 protocol);

/ two-way data transfer between SOTA® and ACS, PC via standard communication channels.

Diagnostics

/ continuous operational performance monitoring (self-diagnostics) during the entire time of operation.

Analysis

/ software for the stored waveforms and daily trends analysis is available for Windows and macOS.

APPLICATION AREA

SOTA® is applied in traction substations of transport and processing companies. SOTA® can also be applied to automate any process without protection system. SOTA® is applied in switchgears (RU) of city transport, metro, electrified railways, industrial enterprises traction substations, as well as for mining/extraction industry enterprises.

SYSTEM CAPABILITIES

Storage and recording

/ recording of traction network electrical parameters waveforms in case of emergency processes;

/ event logging (operations or events in the controlled system);

/ emergency processes data storage for further analysis.

Circuit breaker parameters

/ circuit breaker tripping number metering;

/ circuit breaker position control and indication;

/ circuit breaker resource diagnostics.

Inputs and outputs

/ inputs/outputs general purpose;

/ galvanic isolation of all inputs and outputs, including power supply and analog inputs, to ensure high noise immunity and safety;

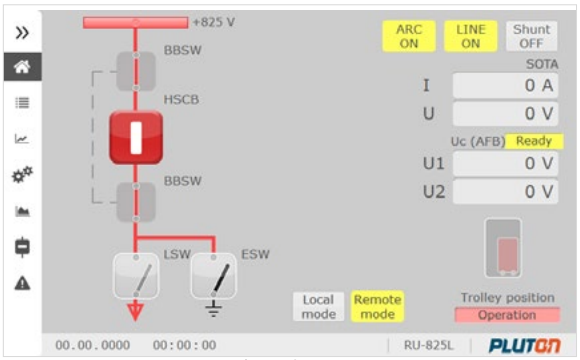
/ high resistance and insulation strength of inputs and outputs to case and to each other to increase the system's resistance to overvoltages in secondary circuits;

/ protection against false operation of digital input circuits in case of insulation faults in control current circuits and short-term induced interference.

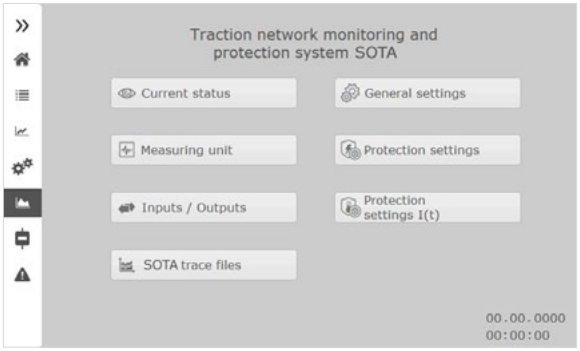
Configuration of the system

/ software-based internal configuration (protections setting, selection of protection features, number of protection levels, etc.);

/ SOTA® internal clock synchronization from external device (SNTP).



a) main screen



b) SOTA® system menu

c) SOTA® waveforms viewing

▲ Screens on visualization panel

Protections settings

/ local and remote input, storage and display of protection settings;

/ information on the number and time of protections operation storage and outpu;

/ storage of up to six settings (values) sets and their switching by external signal.

COMPLIANCE WITH THE INTERNATIONAL STANDARDS

Pluton offers solutions using relay protection and automation devices with IEC 61850 protocol support for simpler and easier equipment integration in substations modern digital solutions.

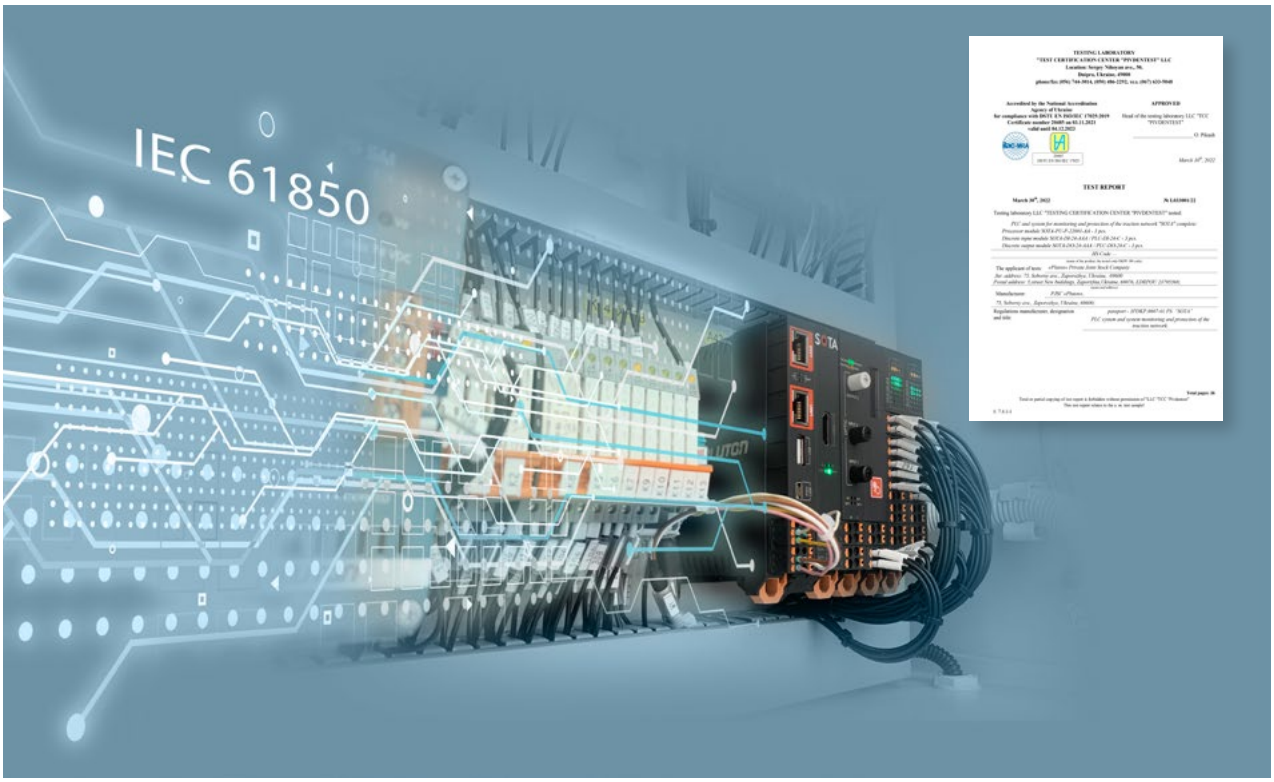
IEC 61850 is a universal standard that regulates unrelated solutions of different manufacturers of protection relays and data transmission systems used in substations.

A number of standards defines requirements to the structure of description for each substation element, peer-to-peer and client-server communication, test methods, design, electromagnetic compatibility, interchangeability of devices, etc.

Pluton SOTA® is successfully type-tested for compliance with International Electrotechnical Commission (IEC) standards.

SOTA® meets the following international standards:

- IEC 61131 (Programmable controllers);
- IEC 60068-2 (Environmental Testing);
- IEC 60255-21 (Electrical Relays — Part 21: Vibration, shock, seismic tests);
- IEC 60255-26 (Measuring relays and protection equipment — Part 26: EMC requirements).



STANDARDS

IEC 61131-1, 2

IEC 60255-26 (EMC)

IEC 60068-2-1,
-2,-6,-14,-27,-30,-31,-78

IEC 60255-21-1,
-2,-32

COMMUNI-CATION PROTOCOLS

IEC 61850

IEC 60870

SNTP

CAN open

Modbus

DNP 3.0

PLC PROGRAMMING LANGUAGE

IEC 61131-3

ELECTRONIC PROTECTIONS

Traction network protection is provided by continuous control and analysis of traction network current and voltage dynamics history with issuing commands to open DC switchgear high speed circuit breaker in case of protection functions set parameters exceed.

Two emergency oscillograph records are generated and stored when one of the protective functions operates:

- Fast Track record (the depth of outreach by time is 100 ms);
- Slow Track record (the depth of outreach by time is 100 s).

SOTA® system also provides long-term monitoring of power supply parameters. Current and voltage values are stored as "daily trend" with 2 points per second resolution.

Types of electronic protections

Protection	ANSI code	
Io	50	instantaneous overcurrent
Imax	76	time overcurrent protection
di/dt	-	current rate of rise protection
ΔI	-	current increment directional protection
Umax	59	overvoltage protection
Umin	27	undervoltage protection
I(t)	49	time/current protection
BF	-	breaker failure
DDL	-	DDL protection
R-prot.	-	impedance protection

ADDITIONAL FUNCTIONS

Optionally, the system is equipped with additional systems (modules) that extend functional range of the system as a whole.

Cable insulation control system

The system continuously monitors cable insulation resistance and in case of insulation degradation gives a warning signal to open high-speed circuit breaker. Cable insulation control system is provided for internal and external cable insulation resistance values measurement in traction networks up to 1500 V DC.

Data transfer between cable insulation control system and SOTA® processing module is going via optical fiber.

Moreover, optical fiber provides galvanic isolation between systems modules and ensures safe usage of device.

Line tester

Line tester allows to determine line impedance before high-speed circuit breaker closing. In case line impedance is lower than the setting parameter, the system issues a prohibition to close high-speed circuit breaker.

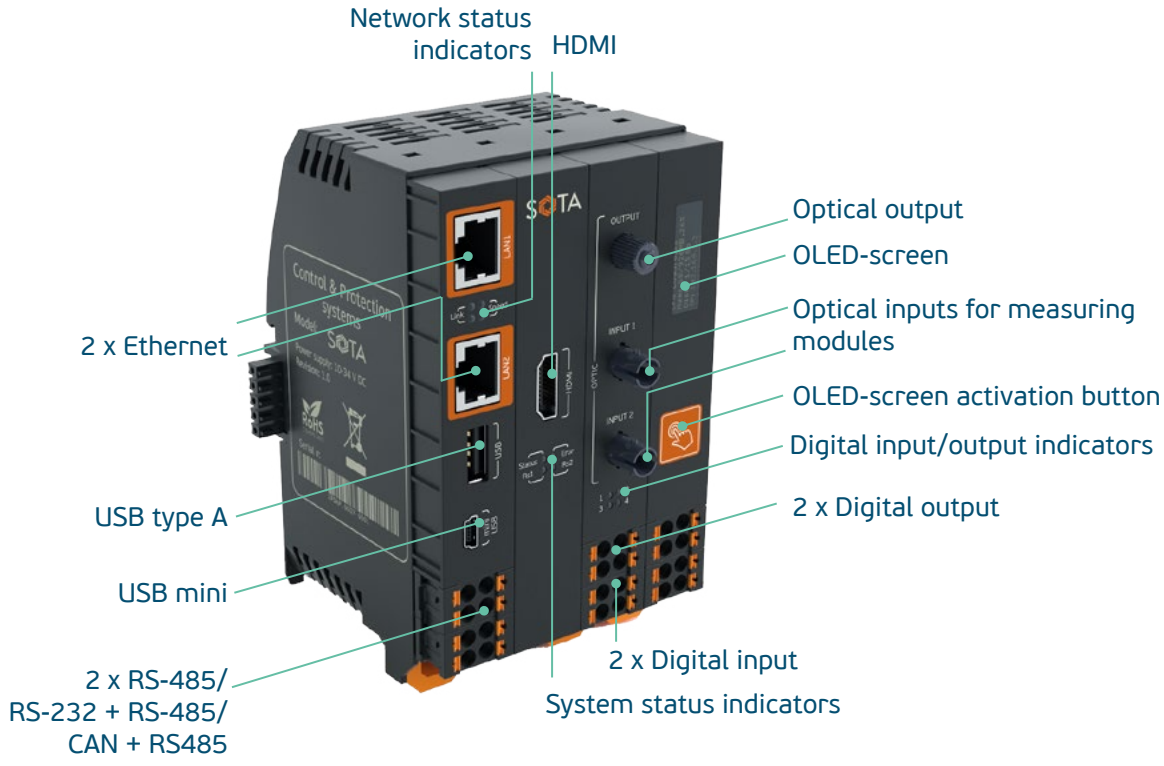
SYSTEM MODULES

Processing module

SOTA® system includes PLC modules, protection system, digital inputs and outputs. PLC and protection system are combined into one processing module. Processing module processes all the data received from measuring module and other additional modules, as well as digital inputs. Processing module is located in low voltage area (control compartment) and consists of several computer systems, interconnected with data busbars.
Measuring and processing modules are interconnected with optic cable that provides transmission of information between modules, as well as galvanic isolation between high voltage measuring circuits and secondary circuits.

Main functions:

- primary processing and storage of current data from measuring module;
- current and voltage values normalization;
- diagnostics and control of data validity received from measuring module;
- protection functions (analysis of data from measuring module according to protection algorithms);
- generation of switching devices emergency tripping signals in accordance with protection functions;
- registration and storage of traction network emergency processes data;
- system events logging;
- system settings storage;
- system self-test;
- communication with traction substation automated control system upper-level system;
- access to changing and configuration of system parameters using Human-Machine Interface (HMI).



▲ Processing module components

PLC-DI-24, PLC-DO-24 extension modules

Extension modules perform primary processing of digital signals, and therefore reducing computational load onto master processing module.

▲ Extension modules

Extension modules are installed onto DIN rail; they also have grouped galvanic isolation. LED indicators, that display actual lines state and modules operation modes, are installed on the front panel.

Main functions of extension modulesя:

- primary processing of digital signals;
- application both in direct proximity to the master controller, and remotely;
- control interface can be either CAN, or RS-485 with a standard (open) protocol. Hot connection to the control busbar is also acceptable;
- two operating modes: with default settings and with user settings (are set via control interface and stored in non-volatile memory);
- connection of wires to the modules does not require special-purpose tools and is implemented on the basis of connections pressure system.

Measuring module

Measuring module is directly connected to voltage and current measurement primary sensors. Current sensor is a resistive element of power circuit (shunt). Voltage sensor is a resistive voltage divider located inside measuring module. It is provided for the measured voltage reduction to the level suitable for further processing in the electronic modules.

Main functions of measuring module:

- matching with primary sensors (shunts, voltage dividers);
- galvanic isolation of low voltage circuits from traction network high potential using static power supply unit;
- processing of analog input electrical quantities to match them with processing module interfaces;
- pre-filtering of input signal based on analog and digital filters;
- transfer of input electrical values analog processed data in processing module using optic cable.

▲ Measuring module

EVENTS AND PARAMETERS LOGGING

SOTA® generates and stores the following records:

- events log;
- failures log;
- emergency oscillograph records;
- daily trends.

Emergency oscillograph records

The records are stored on nonvolatile solid data storage medium that guarantees high reliability and data storage in case of devices power supply interruption.

SOTA® system provides generation and storage of emergency oscillograph records. Emergency oscillograph record is generated when one of protective functions operates.

Emergency records can be:

- viewed using Web interface;
- read by upper level system via Ethernet interface;
- saved on external USB-disk for later analysis using a PC.

Emergency oscillograph records include:

- current and voltage waveform generated directly from the measured values (sampling period 50 μs for Fast track and 100 ms for Slow track);
- digital inputs and outputs state diagram for the entire duration of voltage and current waveform recording;
- track generation astronomical time;
- kind of tripped protection;
- tripping protections settings.

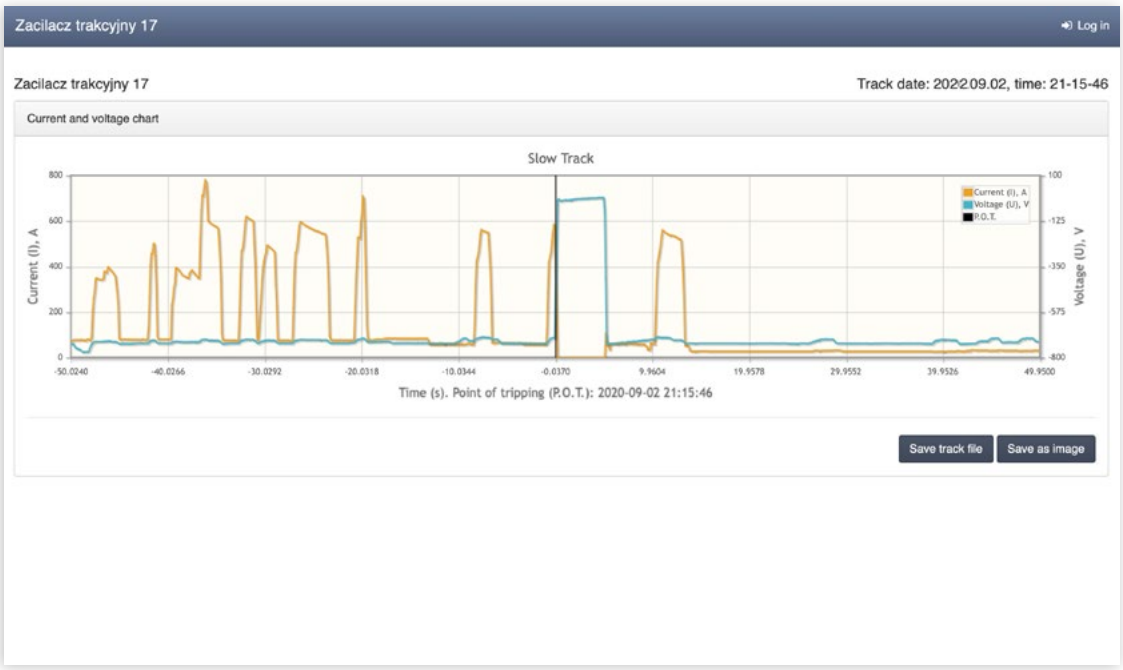
The length of Fast track and Slow track waveforms is fixed, and contains 2046 current and voltage values. Time of each record is:

- Fast track — 100 ms;
- Slow track — 100 s.

Long-term monitoring

SOTA® accumulates data on the power network parameters, which are saved to file for later analysis (trend file). The system stores files for the last 30 days of module operation.

a) Fast track



b) Slow track

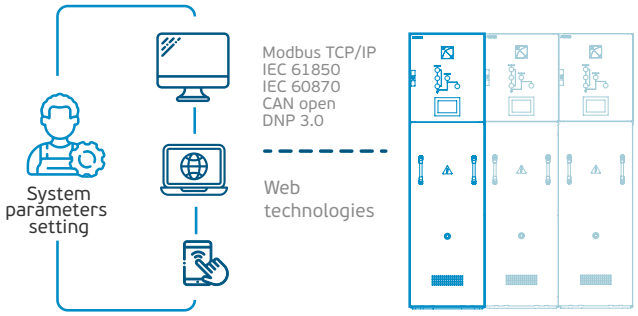
▲ Emergency oscillograph records

PARAMETERS SETTING

SOTA® provides the following parameters setting methods for both the system itself and protective functions parameters:

- Web-based remote Human-Machine interface;
- remote access to the device using Modbus TCP/IP, IEC or other supported by the system protocols for upper level systems and power supply control systems, etc.

Web-based remote Human-Machine interface is an integrated Web-server in each SOTA® processing module. It does not require any additional software to be installed on PC. This interface is used to configure, display and analyze data accumulated by SOTA® system.



Communication with SOTA® Web-server can be done via PC, tablet or smart phone connection. SOTA® Web-server operation requires only a Web-browser installed on the device.

Human-Machine interface languages are English, Ukrainian, Russian. HMI can also include support for other languages (German, French, Polish, Swedish, Romanian). This makes it easy and convenient to use in various regions and countries around the world.

▲ Web-based remote interface

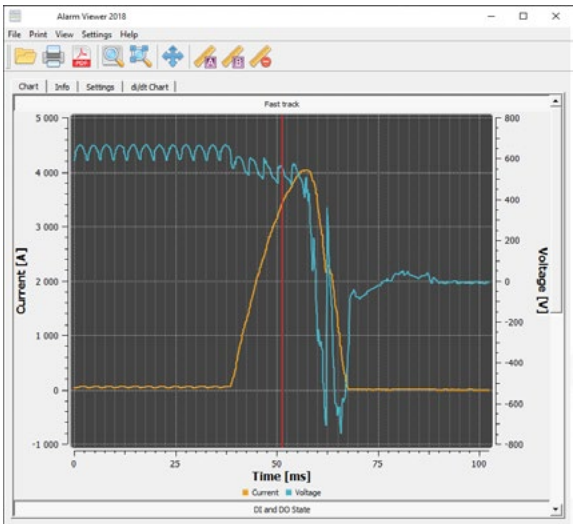
VIEWING EMERGENCY RECORDS IN ALARM VIEWER 2018

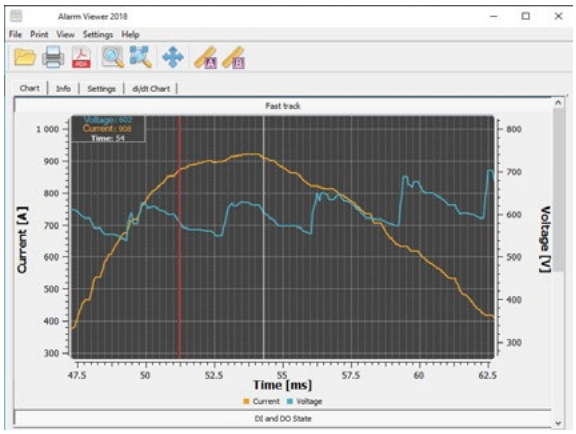
Alarm Viewer 2018 application is designed to view SOTA® alarm records.

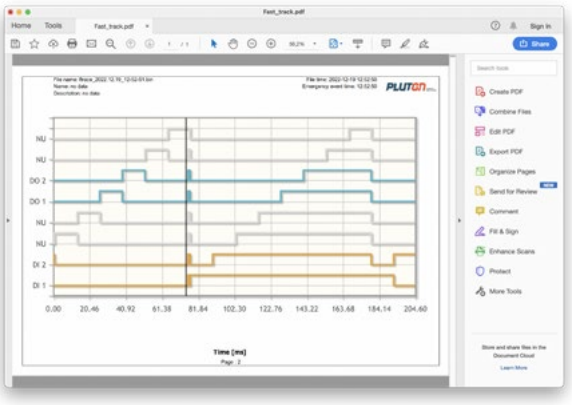
The application is implemented as a standalone one for Windows and macOS. It is installed on a PC and allows to locally view, analyze and print out SOTA® emergency records saved to USB flash drives.

Main functions:

- cross-platform (Windows and macOS);
- multilingual interface with subsequent support for additional languages;
- possibility to print directly from the application using standard dialog boxes;
- possibility to export to PDF directly from the application for further analysis and viewing without using the application;
- simple and convenient installer and uninstaller for Windows;
- standard installation and uninstallation in macOS;
- convenient diagram navigation (move, zoom);
- availability of detailed information about emergency record;
- two measuring markers with calculation of their values difference;
- possibility to display current curve for convenient viewing in case of wrong shunt polarity;
- user-friendly, intuitive interface.







MAIN TECHNICAL SPECIFICATIONS OF SOTA® SYSTEM

Main parameters of protection system module			
Number of current measuring channels		units	Up to 2
Number of voltage measuring channels		units	1
Type of current sensor		-	Shunt
Power circuit voltage measuring range		V	-2000 ... +2000* -8000 ... +8000*
Input voltage range for power circuit current measuring channel (DC generated voltage on shunt)		V	-0.4 ... +0.4
Current measuring range		A	$I_{max} = \pm \frac{0,4*I_{sh}}{U_{sh}}$ I_{sh} — shunt rated current; U_{sh} — voltage drop on shunt under rated current
Measured values sampling period		μS	50
Current measuring accuracy (of I_{sh})		%	0.5 (max)
Voltage measuring accuracy, of measuring range		%	0.5 (min)
Insulation strength between measuring module power circuit and power supply circuit		kV	10 (30)*
Measured values		-	Current (current channels) Voltage (voltage channel) Power (calculated) Energy (calculated)
External signals			
Number of high speed digital outputs		units	2
Digital inputs designation (is set individually for each output)		-	Signals issuing under one or several protection functions tripping
Number of digital inputs		units	2
Digital inputs designation (is set individually for each input)		-	HSCB condition control External signal for waveform recording
Protection functions	Io	ANSI 50	Instantaneous overcurrent
	Imax	ANSI 76	Time overcurrent protection
	di/dt	-	Current rate of rise protection
	ΔI	-	Current increment directional protection
	Umax	ANSI 59	Overvoltage protection
	Umin	ANSI 27	Undervoltage protection
	I(t)	ANSI 49	Time/current protection
	BF	-	Breaker failure
	DDL	-	DDL protection
	R-prot.	-	Impedance protection (R-protection)

MAIN TECHNICAL SPECIFICATIONS OF SOTA® SYSTEM

Protection functions			
Period of data processing by protective functions algorithms	μS	50/1000	
Number of settings groups	-	up to 6 (IEC 61850)	
Power supply			
Rated operating voltage	V	⎓ 24; 48, 110; 220	~110; 220
System consumed power, max	W	18	
Permissible voltage long-term tolerances	%	-15 ... +10	
Communication interfaces			
Data transfer interfaces	-	Ethernet RS-485	RS-232 CAN
Data transfer protocols	-	Web technologies IEC-61850 Edit 2 Modbus TCP	DNP3 IEC 60870-5-104 JSON SNTP
Reliability			
Mean Time Between Failures (MIL-HDBK-217F)	hours	100 000	
Total average lifetime (under condition of the required technical maintenance activities provision)	years	25	
Design			
Modules protection degree in acc. with DIN VDE 0470 and EN 60529 or IEC 529	-	IP 3X	
Cooling	-	natural, air	
Type of modules mounting	-	DIN-rail (TH 35, EN 50022)	
Measuring and logging functions			
Measured values	-	Current Voltage Power Energy	HSCB trippings counter System operation time tracking Daily trend (current and voltage)
Number of recorded waveforms in case of emergency event**	units	2 (Fast track, Slow track)	
Data stored in emergency oscilloscope records	-	Current curve Voltage curve Digital inputs and outputs state diagram Astronomical time Type of tripped protection	

MAIN TECHNICAL SPECIFICATIONS OF SOTA® SYSTEM

Measuring and logging functions		
Emergency oscilligraph records coverage depth	points	2046
Number of recorded waveforms in case of emergency event	units	200 (for each measured value)
Fast track		
- signals sampling frequency	kHz	20
- record time coverage depth	ms	100
- prehistory record time coverage depth***	points	Set 0 - 2046
Slow track		
- signals sampling frequency	Hz	20
- record time coverage depth	s	100
- prehistory record time coverage depth***	s	Set 0 - 100
Daily trend		
- signals sampling frequency	Hz	2
- 1 trend record time coverage depth	hours	24
- number of trend files	units	30
Local human interaction interfaces		OLED screen with touch button
Operating conditions		
Ambient operating temperature range	°C	-10 ... +60
Relative air humidity, under temperature (upper value)	%	60, 20 °C (80, 25 °C)

* depending on measuring module design, for application in city electric transport with traction network voltage up to 1000 V or for application in railway transport with traction network voltage up to 4000 V
** one of protections tripping is considered to be emergency event
*** prehistory is a diagram of measured values up to emergency event occurrence

MAIN TECHNICAL CHARACTERISTICS OF INPUT AND OUTPUT DISCRETE SIGNALS MODULES

PLC-DI-24		
Input digital signals module		
Number of digital inputs	-	24 (one galvanically isolated group)
Rated input voltage, DC	V	24
Input voltage range, ON state (log. 1), DC	V	10 – 34
Input current, ON state (log. 1) (upon input voltage 10 V < U < 30 V)	mA	2.8 – 3.6 per channel
Consumption power in +5 V circuit	W	0.35
PLC-DO-24		
Output digital signals module		
Number of digital outputs	-	24 (one galvanically isolated group)
Rated output voltage, DC	V	24
Output DC, max.:		
- upon all public keys	mA	50
- upon 12 public keys of 24 available	mA	100
Output overload protection actuation current, DC	A	1.4 – 2.0
Output resistance of public key	mΩ	165 (max)
Current of load failure monitoring generator	uA	80 per channel
Maximum output switching frequency	kHz	1
Consumption power in +5 V circuit	W	0.5
Electrical insulation resistance of galvanically isolated circuits (upon test voltage frequency 50 Hz and testing time 1 min)	V	1000
Module power supply voltage in +24 V DC circuit	V	10 – 34
Module power supply voltage in +5 V DC circuit	V	4.7 – 5.5
Environmental conditions		
Operational temperature	°C	from -10 up to +60
Storage temperature	°C	from -40 up to +70
Relative humidity	-	up to 80 % with no condensed water
Atmospheric pressure	kPa	from 86 up to 106 (645 – 795 mm Hg)
Operation mode	-	Continuous
Cooling	-	Natural
Installation	-	DIN-rail, 35 mm
Protection level DIN EN 60529:2014	-	IP 20

SOTA® SYSTEM TYPE TESTING

Electric tests	EN 60255-26 EN 61131-2	
EMC compliance tests		
Radio interference voltage on power supply terminals	IEC 61000-6-4 CIS PR 22, class A	Frequency range: (0.15 — 30) MHz Frequency range: (30 — 1000) MHz
Radio interference field intensity	IEC 61000-6-4 CIS PR 22, class A	Measuring distance: 3 m
Immunity:		
• radiated electromagnetic field immunity	EN 60255-26 EN 61000-4-3	Frequency range: (80 — 1000) MHz, Field intensity: 10 V/m
• conducted interference immunity, inducted by radio-frequency electromagnetic field	EN 60255-26 EN 61000-4-6	Frequency range: (0.15 — 80) MHz Interference voltage: 10 V
• nanosecond pulses immunity	EN 60255-26 IEC 61000-4-4	Test pulses amplitude: • signal and feed lines ± 4 kV • communication lines ± 2 kV Pulse repetition frequency: 5 kHz Test pulse: 5/50 ns
• electrostatic discharge tolerance (EDS)	EN 60255-26 IEC 61000-4-2	Air discharge ± 8 kV Contact discharge ± 6 kV
• microsecond pulse interference immunity	EN 60255-26 IEC 61000-4-5	Test pulse: 1.2/50 μS Test pulses amplitude: • signal and feed lines: two-wire ± 2 kV earth-return ± 4 kV • communication lines: earth-return ± 4 kV
• power frequency magnetic field immunity	IEC 60255-26 IEC 61000-4-8	Magnetic field intensity: 30 A/m
• pulsed magnetic field immunity	IEC 60255-26 IEC 61000-4-9	Magnetic field intensity: 300 A/m
• power failures and interruption resistance	EN 60255-26 IEC 61000-4-11 IEC 61000-4-29	Power failure: U int. min — 70 % (500 ms) U int. min — 40 % (200 ms) Power interruption: 20 ms
• power supply pulsing resistance	КТ 60255-26 IEC 61000-4-17	Peak-to-peak pulsation 15 % Duration 10 min

SOTA® SYSTEM TYPE TESTING

Mechanic tests Sinusoidal vibration influence immunity	IEC 60068-2-6	Frequency: 2-200 Hz; Acceleration amplitude15 m/s^2 (1.5 g) Scanning rate: 1 octave/min. Duration: 20 cycles/axe In 3 orthogonal axes
Climatic tests		
• Ad test: Cold, in operation	IEC 60068-2-1	-10 °C Holding: 72 h.
• Ab test: Cold, off-load	IEC 60068-2-1	-40 °C Holding: 72 h.
• Bd test: Sensible heat, in operation	IEC 60068-2-2	+60 °C Holding: 72 h.
• Bb test: Sensible heat, off-load	IEC 60068-2-2	+70 °C Holding: 72 h.
• Nb test: Temperature drift	IEC 60068-2-14	Minimum temperature -40 °C Maximum temperature +70 °C Holding: 5 h. 5 cycles
• Cab test: Damp heat. Constant mode	IEC 60068-2-78	Temperature: +40 °C Humidity: 93 % Holding: 48 h.
• Db test: Damp heat. Cyclic mode	IEC 60068-2-30	+25 °C/ 95 % -> +55 °C/ 93 % Holding: 12 h. 2 cycles +55 °C/ 93 % -> +25 °C/ 95 % Holding: 12 h. 2 cycles

PLUTON Rail PTY LTD

PO Box 385,
Adelaide SA 5092 Australia
Telephone/Fax:
+61 (42) 034-44-08

E-mail: info@plutonrail.com.au
plutonrail.com.au

SOTA 22-en_au